NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE 3017

AXIAL-LOAD FATIGUE TESTS ON NOTCHED AND UNNOTCHED SHEET SPECIMENS OF 61S-T6 ALUMINUM ALLOY, ANNEALED 347 STAINLESS STEEL, AND HEAT-TREATED 403 STAINLESS STEEL

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SUMMARY

Axial-load fatigue tests at a stress ratio of zero were performed on notched and unnotched sheet specimens of 61S-T6 aluminum alloy and 347 and 403 stainless steels. Special emphasis was placed on tests at high stress levels which produce failures in small numbers of cycles. The stress-concentration factors effective in fatigue of notched specimens were found to be somewhat less than the theoretical elastic values at low stresses and were approximately equal to one at the ultimate strength. The minimum life to failure at stresses near the ultimate strength was drastically reduced with increasing stress-concentration factor.

INTRODUCTION

The experimental investigation reported herein was carried out to provide information on the fatigue properties of 61S-T6 aluminum alloy, annealed 347 stainless steel, and heat-treated 403 stainless steel. Unnotched specimens and specimens containing notches were tested under repeated tensile stresses at a stress ratio (ratio of minimum stress to maximum stress) of zero. Since a knowledge of fatigue properties at high stresses is useful in some design problems, this investigation included tests in this range.

The primary purpose of this paper is to present the results of the tests. Some comparisons with other work are also included.

The materials used to prepare specimens for this investigation were supplied by Bell Aircraft Company.

SYMBOLS

K_F	stress-concentration factor effective in fatigue (ratio of stress in an unnotched specimen at a given lifetime to stress in a notched specimen at same lifetime)
K_P	plastic stress-concentration factor (ratio of maximum local plastic stress to average stress in net section)
K_T	theoretical stress-concentration factor (ratio of maximum local elastic stress to average stress in net section)
N	cycles
R	stress ratio (ratio of minimum stress to maximum stress)
S	average stress in net section

MATERIALS

The 61S-T6 aluminum-alloy material used in the present tests came from a single sheet 4 feet wide, 12 feet long, and 0.125 inch thick. The sheet was painted with zinc chromate to protect the surface during specimen preparation. The sheet was cut into blanks according to the layout shown in figure 1 and each blank was labeled as indicated. Standard specimens (ref. 1) for tensile and compressive static tests were cut from blanks taken at random from the sheet.

The annealed 347 stainless-steel material also came from a single sheet 3 feet wide, 10 feet long, and 0.064 inch thick, painted with zinc chromate. The specimen blanks were cut and labeled as indicated in figure 2.

The 403 stainless-steel material was cut from two sheets 3 feet wide, 10 feet long, and 0.050 inch thick. These sheets were cut into pieces $7\frac{3}{4}$ by 17 or $10\frac{1}{4}$ by 17 as indicated by the heavy lines in figure 2 and were heat-treated to Rockwell C 40 to 41 by Bell Aircraft Company. The location of these pieces within the original sheets was not available. The pieces were, therefore, arbitrarily numbered in consecutive order and each piece was cut into specimen blanks, as shown by the light lines in figure 2, to provide notched and unnotched specimens. Since the material had become warped during heat treatment, specimens were machined from blanks which were selected for minimum warpage or with warped portions remote from the central portion of the specimen. The effects of the warpage on the results is discussed subsequently.

SPECIMEN PREPARATION

The dimensions of specimens used in this investigation are given in figure 3. The notched specimens are similar to those tested at Battelle Memorial Institute (ref. 2) and have elastic stress-concentration factors K_T equal to 2 and 4 (ref. 3).

As is known, the technique used in specimen preparation can have an important effect on the results of fatigue tests (see ref. 4). The following explanation of the procedures used in preparing specimens for this investigation is therefore given in detail. In general, these procedures are felt to have produced little residual stress in the machined surfaces, but no detailed studies were made to obtain a quantitative check.

The unnotched specimens were clamped in stacks about 1 inch thick and machined in a lathe to produce the 12-inch radius of curvature at the edges. Successively lighter cuts were taken with the last two or three cuts removing about 0.0005 inch. The material was rotated at a speed of approximately 30 rpm.

The notched specimens were machined along the parallel edges in stacks and then the notches were machined in each specimen separately. The specimen was mounted on a combination turn-table and cross-slide support and the notches were cut with a milling cutter rotating about an axis normal to the plane of the sheet. Milling tools with helical cutting edges and 5/16-inch diameters were used to cut the specimens which have a notch radius of 0.3175 inch. The cutter speed was constant at 1,500 rpm for 61S-T6 aluminum-alloy specimens and at 675 rpm for stainless-steel specimens. Very slow manual feeds were used. Each cut removed 0.0005 inch or less in the final stages of machining. The same procedure was used for notches with a radius of 0.057 inch except that cutters with 0.100-inch diameter were used.

The surfaces of all specimens were left unpolished, but sharp edges were slightly rounded by hand with fine emery paper. The paper was moved in a longitudinal direction to leave no transverse scratches. In the case of the 61S-T6 notched specimens, the edges in the notches were removed with a pad of steel wool spinning in the jaws of a 1/4-inch drill. The specimen was held against this pad with very light pressure so that only the edges were cut. The sharp edges of notches in stainless-steel specimens were removed with emery paper rolled into a small cylinder and rotated by hand.

FATIGUE TESTING PROCEDURE

All specimens were tested under axial load at a stress ratio of zero. Three types of testing machines were used to cover the complete range of the S-N curves.

Most of the tests were performed in subresonant fatigue testing machines with capacities of 20,000 pounds. These machines and the associated load measuring apparatus are described in detail in reference 5. The probable error of the load measuring apparatus is approximately 1 percent. Frequent monitoring revealed that the loads rarely changed as much as 3 percent during any given test.

Tests in which failure occurred in less than 10,000 cycles were impractical to perform with these fatigue testing machines because of the trial-and-error procedure required to start each test. Consequently, a machine hydraulically operated at 180 cpm was used for tests in which failure was expected to occur in 500 to 10,000 cycles. Tests in which failure was expected to occur in less than 500 cycles were performed in static testing machines which were manually controlled to apply loads at approximately 2 cpm.

All specimens except those tested in static testing machines were clamped within guide plates similar to those described previously (refs. 5 and 6). For all specimens tested at stress levels higher than the yield strength of the material, the first cycle of load was applied manually to produce the plastic deformation corresponding to that load. This procedure simplified the maintenance of the desired mean load at the start of each of these tests.

TEST RESULTS AND DISCUSSION

Static Tests

The results of static tensile and compressive tests on standard test coupons are presented in table I. The 61S-T6 aluminum-alloy material had properties exceeding the minimum mechanical properties listed in table 3.111(f) of reference 7. The 347 stainless-steel material had properties exceeding those listed in table 2.111(c) of reference 7. Stress-strain curves for each material were obtained by averaging four autographically recorded curves and are presented in figure 4.

Static Tests of Fatigue Specimens

Results of static tensile tests of each type of fatigue specimen are included in tables II to IV and figures 5 to 7. The differences between static strengths of notched and unnotched specimens made of the same material appear to be outside the range of probable error in the tests. In all but one case (347 stainless-steel material with $K_T = 4$) the notched specimens had greater static strengths than the unnotched specimens made of the same material. The increased strength in notched specimens can be considered to be due to the development of a multiaxial tensile stress which, in effect, reduces the maximum shear stress and thus retards fracture; however, the present knowledge of static strength of notched parts does not permit quantitative predictions.

Fatigue Tests

The results of fatigue tests on 61S-T6 aluminum-alloy specimens are given in table II and are plotted in the form of S-N curves in figure 5. Similarly, the data for 347 and 403 stainless-steel specimens are given in tables III and IV and are plotted in figures 6 and 7, respectively. In the presentation of data, no distinction is made among unnotched specimens failing within the middle inch of the specimen. In this region the stresses are within 3 percent of the stress which occurs at the minimum section. Unnotched specimens occasionally failed at sections somewhat more removed from the middle of the specimen. Since stresses at these sections were definitely out of the range of possible variations in applied stresses, the specimens which failed outside the middle inch are identified in the tables and figures.

In the warped 403 stainless-steel specimens the minimum radius of curvature of the sheet surface, as measured by a curvature gage with a 5-inch gage length, was 50 inches; thus, the maximum stress resulting from clamping the specimens between flat plates was approximately 15 ksi. This stress, however, usually occurred in sections remote from the central portion of the specimens. Where a curvature appeared at the critical section, only 30 percent of the specimens developed initial fatigue cracks on the side of the specimen where the bending stress was tensile. These observations lead to the conclusion that the stresses due to bending did not affect the results significantly.

Minimum Life at High Stresses

In tests on unnotched specimens those which survived 1 cycle of load near the ultimate tensile strength were found to withstand approximately 10^4 cycles of that load before failure occurred. The S-N curves (figs. 4 to 6) are, therefore, shown dashed between this minimum life and 1/2 cycle. An exception appears in the tests of the 347 stainless-steel material where four failures occurred between 100 and 10^3 cycles. This observation of minimum life to failure in unnotched specimens appears to be consistent with most tests previously reported.

For specimens containing notches with an elastic stress-concentration factor K_T of 2, those surviving 1 cycle of load usually survived approximately 10^3 cycles before failure. Similarly, specimens containing notches with $K_T = 4$ generally survived 100 cycles before failure if they survived the first cycle. Thus, the minimum life was reduced by a factor of 10 each time the theoretical stress-concentration factor was doubled. No way of predicting this behavior is apparent at present. The same ratios of cycles to failure are found to exist for stresses in the vicinity of two-thirds of the ultimate strength.

Fatigue Stress-Concentration Factors

At lower stresses the S-N curves for unnotched specimens and specimens containing notches appear to be roughly parallel. Fatigue stress-concentration factors K_F have been computed by dividing the stress in an unnotched specimen by the nominal stress in a notched specimen which failed in the same number of cycles. These factors are plotted against maximum average stress in the net sections in figures 8, 9, and 10 for the three materials. In each case the curve for K_F is seen to have a maximum value less than K_T for low stresses and progressively lower values for higher stresses. The differences between K_T and the maximum value of K_F may be expected to be due to size effect (ref. 8). Since, however, current predictions for size effect in fatigue are restricted to completely reversed stress cases, no prediction of the magnitude of the maximum value of K_F is possible at this time.

Previous work (refs. 3, 9, and 10) has shown that plastic deformation reduces the severity of stress concentration during the first load application and that the magnitude of the plastic stress-concentration factors K_P can be predicted as long as the strains are small. Griffith (ref. 9) has also shown that, at least during the first 100 cycles of a load which produces plastic deformations at a discontinuity, the local strains and stresses oscillate between the values observed at the end of the first 1/2 cycle and at the end of the unloading part of the first cycle.

If the local stresses in notched specimens are assumed to remain unchanged throughout a fatigue test and are assumed to produce fatigue failures in the same number of cycles as do stresses of the same magnitude in unnotched specimens, then the curves of K_F and K_P would be expected to be equivalent. The dashed curves in figures 8 to 10 represent the curves for K_P which were calculated for each of the notched specimens by use of the stress-strain curves appropriate for each material and the method described in reference 3.

For the 61S-T6 aluminum-alloy material (fig. 8) the curve of K_F lies below the curve for K_P in the region of stresses less than about 15 ksi for $K_T = 4$ and 28 ksi for the $K_T = 2$ configurations. These stress levels correspond to approximately 7×10^4 cycles to failure (see fig. 4) and this life is approximately the minimum life of unnotched specimens which failed under repeated stress. For higher stresses the curves of K_F and K_P are in fair agreement. The agreement at high stresses, however, does not permit the use of the curve of K_P in the prediction of the S-N curves for notched specimens inasmuch as it occurs in a region where the S-N curves for unnotched specimens are horizontal.

In the case of the 347 stainless-steel material (fig. 9) the curves of K_F lie above the curves for K_P for all stress levels. This lack of agreement is probably due to the fact that the endurance limit for unnotched specimens (55 ksi) is approximately 20 percent higher than the yield strength (45.6 ksi) and corresponds to approximately $2\frac{1}{2}$ percent strain on the tensile stress-strain curve for the material. Since such large plastic deformations are experienced before any failure occurs by fatigue, a relation between fatigue stress-concentration factors and the original stress-strain properties of the material probably cannot be expected.

The comparison between K_F and K_P for the 403 stainless-steel material (fig. 10) is similar to that for the 61S-T6 aluminum-alloy material as discussed previously.

CONCLUDING REMARKS

Sheet specimens containing no notches or notches with theoretical stress-concentration factors K_T of 2 and 4 and made of 61S-T6 aluminum alloy, annealed 347 stainless steel, and heat-treated 403 stainless steel have been tested under axial load at a stress ratio of zero. The results indicate that failures in unnotched specimens subjected to repeated stresses near the ultimate strength occurred in roughly 10^4 cycles; in notched specimens with $K_T = 2$ failure occurred in about 10^3 cycles; and in notched specimens with $K_T = 4$ failure occurred in about 100 cycles.

In the range of stress where failure occurred by fatigue, the effective stress-concentration factor K_F decreased from a maximum value somewhat less than the theoretical factor at low stresses to a minimum value approaching or less than one at the static failing stress. A comparison between K_F and plastic stress-concentration factors K_P revealed that in the cases of the 61S-T6 aluminum-alloy material and the 403 stainless-steel material the values were approximately the same at high stresses but in the case of the 347 stainless-steel material there appears to be no correlation between the two factors.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., June 23, 1953.

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TABLE I.- TENSILE AND COMPRESSIVE PROPERTIES OF MATERIALS TESTED

Material	Ultimate tensile strength, ksi	Tensile yield strength (offset = 0.2 percent), ksi	Elongation in 2 inches, percent	Compressive yield strength (offset = 0.2 percent), ksi
61S-T6 aluminum alloy	47.0 [a]42.0	42.0 [a]36.0	17 [b]10	42.8 [a]35.0
347 stainless steel	92.0 [c]75.0	45.6 [c]30.0	61	29.9 [c]35.0
403 stainless steel	190.0	153.0	8	160.8

[a]Values obtained from table 3.111(f) in ref. 7.

[b]Value obtained from table 38 in ref. 11.

[c]Values obtained from table 2.111(c) in ref. 7.

TABLE II.- FATIGUE TEST RESULTS FOR 61S-T6 ALUMINUM-ALLOY MATERIAL

UNDER DIRECT STRESS AT R = 0

(a) Unnotched sheet specimens

Specimen	Maximum stress, ksi	Fatigue life, cycles	Speed, cpm	Remarks
D1B10	47	38,000	1,800	
D1B4	47	56,000	1,800	
D1B45	46.4			Static test to failure
D1B46	46.3	27,269	180	
D1B39	46.2			Static test to failure
D1B16	46	62,000	1,800	
D1B28	46	70,000	1,800	
D1B34	45	58,000	1,800	
D1B22	45	89,000	1,800	
D1B47	40	91,000	1,800	
D1B3	40	100,000	1,800	Failed 0.05 in. out of middle inch
D1B40	40	152,000	1,800	
D1B35	35	121,000	1,800	
D1B29	35	257,000	1,800	Failed 0.30 in. out of middle inch
D1B33	35	555,000	1,800	
D1B15	30	270,000	1,800	Failed 0.55 in. out of middle inch
D1B44	30	281,000	1,800	
D1B38	30	422,000	1,800	Failed 0.65 in. out of middle inch
D1B23	30	542,000	1,800	
D1B9	30	549,000	1,800	Failed 1.00 in. out of middle inch
D1B20	30	575,000	1,800	Failed 0.45 in. out of middle inch
D1B41	30	1,169,000	1,800	
D1B26	30	1,809,000	1,800	
D1B31	28	11,346,000	1,800	
D1B13	28	41,182,000	1,800	
D1B37	27	325,000	1,800	
D1B43	27	1,331,000	1,800	
D1B27	25	403,000	1,800	Failed 0.76 in. out of middle inch
D1B2	25	1,064,000	1,800	Failed 0.55 in. out of middle inch
D1B21	25	88,719,000	1,800	
D1B32	25	89,122,000	1,800	
D1B14	25	92,802,000	1,800	Did not fail

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TABLE II.- FATIGUE TEST RESULTS FOR 61S-T6 ALUMINUM-ALLOY MATERIAL

UNDER DIRECT STRESS AT R = 0 - Continued

(b) Notched sheet specimens, $K_T = 2$

Specimen	Maximum stress, ksi	Fatigue life, cycles	Speed, cpm	Remarks
D1A6	49.9			Static test to failure
D1C47	48.6			Static test to failure
D1C41	48.5			Static test to failure
D1A42	48.5	642	180	
D1C34	48.5	3,063	180	
D1A36	47	3,127	180	
D1A38	47	4,682	180	
D1A48	45	6,550	180	
D1A34	45	7,195	180	
D1A28	42	10,988	180	
D1A46	40	7,000	1,800	
D1A45	40	8,000	1,800	
D1A13	40	12,000	1,800	
D1C38	35	23,000	1,800	
D1A27	35	25,000	1,800	
D1C30	35	30,000	1,800	
D1A39	30	43,000	1,800	
D1C42	30	64,000	1,800	
D1C12	30	124,000	1,800	
D1C24	25	101,000	1,800	
D1A10	25	136,068	180	
D1A15	25	160,000	1,800	
D1A31	25	281,000	1,800	
D1A25	20	336,000	1,800	
D1A33	20	1,136,000	1,800	
D1A21	20	1,314,000	1,800	
D1C36	18	189,000	1,800	Failed at surface flaw near notch
D1A18	18	493,000	1,800	
D1A19	18	661,000	1,800	
D1A14	18	764,000	1,800	
D1A8	16	721,000	1,800	
D1A7	16	10,487,000	1,800	
D1A37	16	12,010,000	1,800	
D1A41	14	23,008,000	1,800	
D1C32	14	30,679,000	1,800	
D1A26	14	49,254,000	1,800	
D1A20	11.8	65,730,000	1,800	Did not fail

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TABLE II.- FATIGUE TEST RESULTS FOR 61S-T6 ALUMINUM-ALLOY MATERIAL

UNDER DIRECT STRESS AT R = 0 - Concluded

(c) Notched sheet specimens, $K_T = 4$

Specimen	Maximum stress, ksi	Fatigue life, cycles	Speed, cpm	Remarks
D1C2	49.5			Static test to failure
D1C26	49.1			Static test to failure
D1C15	47	195	2	
D1C14	45	394	180	
D1C19	45	690	180	
D1C29	42.5	388	180	
D1A9	42.5	525	180	
D1A44	40	657	180	
D1C11	40	688	180	
D1C27	35	1,410	180	
D1A4	35	2,235	180	
D1C33	30	2,700	180	
D1C22	30	3,735	180	
D1C31	25	6,157	180	
D1C37	25	6,489	180	
D1C3	25	6,765	180	
D1C45	20	20,000	1,800	
D1C39	20	22,000	1,800	
D1C5	15	74,271	180	
D1A3	15	108,000	1,800	
D1C23	15	115,000	1,800	
D1A2	12	639,000	1,800	
D1C1	10	424,000	1,800	
D1C35	10	429,000	1,800	
D1C7	8	26,535,000	1,800	
D1C8	8	30,468,000	1,800	
D1C13	6	96,481,000	1,800	Did not fail
D1C25	6	103,261,000	1,800	Did not fail

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TABLE III.- FATIGUE TEST RESULTS FOR 347 STAINLESS-STEEL MATERIAL

UNDER DIRECT STRESS AT R = 0

(a) Unnotched sheet specimens

Specimen	Maximum stress, ksi	Fatigue life, cycles	Speed cpm	Remarks
E1B26	89.9			Static test to failure
E1C12	88	403	180	
E1C17	88	675	180	
E1B22	85	263	180	
E1B28	85	740	180	
E1C16	85	9,363	180	
E1A28	85	12,540	180	
E1B25	80	94,418	180	
E1B17	80	98,000	1,800	Failed 0.75 in. out of middle inch
E1B24	75	49,340	180	
E1B16	73.4	45,000	1,800	
E1B12	73.2	72,000	1,800	
E1B11	70	113,000	1,800	
E1B15	70	153,000	1,800	
E1B7	65	168,000	1,800	
E1B5	65	204,000	1,800	
E1B23	60	206,000	1,800	
E1B27	60	233,000	1,800	
E1B18	57	478,000	1,800	
E1B19	57	697,000	1,800	Failed 1.40 in. out of middle inch
E1B6	55	379,000	1,800	
E1B1	55	503,000	1,800	Failed 0.60 in. out of middle inch
E1B2	55	53,543,000	1,800	Did not fail
E1B9	53	59,529,000	1,800	Did not fail
E1B13	53	72,050,000	1,800	Did not fail
E1B10	50	30,261,000	1,800	Did not fail
E1B14	50	36,087,000	1,800	Did not fail

TABLE III.- FATIGUE TEST RESULTS FOR 347 STAINLESS-STEEL MATERIAL

UNDER DIRECT STRESS AT R = 0 - Continued

(b) Notched sheet specimens, $K_T = 2$

Specimen	Maximum stress, ksi	Fatigue life, cycles	Speed, cpm	Remarks
E1A18	97			Static test to failure
E1A12	95.2			Static test to failure
E1D13	94.5			Static test to failure
E1A17	90	1,219	2	
E1D9	85	82	180	
E1A22	85	2,603	180	
E1A10	85	5,195	180	
E1A16	80	6,091	180	
E1A14	80	9,263	180	
E1C14	75	9,651	180	
E1A4	75	12,660	180	
E1C9	70	13,556	180	
E1A8	70	15,207	180	
E1A11	65	27,000	1,800	
E1D8	60	18,000	1,800	
E1D16	60	35,000	1,800	
E1C7	55	50,000	1,800	
E1C3	55	54,000	1,800	
E1C1	50	84,000	1,800	
E1A25	50	94,236	180	
E1D20	50	98,000	1,800	
E1A2	45	121,000	1,800	
E1D24	45	177,000	1,800	
E1A6	40	424,000	1,800	
E1D12	40	624,000	1,800	
E1C5	40	868,000	1,800	
E1A3	39	44,939,000	1,800	Did not fail
E1A7	38	56,027,000	1,800	Did not fail
E1A26	37	65,985,000	1,800	Did not fail
E1C28	35	57,692,000	1,800	Did not fail

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TABLE III.- FATIGUE TEST RESULTS FOR 347 STAINLESS-STEEL MATERIAL

UNDER DIRECT STRESS AT R = 0 - Concluded

(c) Notched sheet specimens, $K_T = 4$

Specimen	Maximum stress, ksi	Fatigue life, cycles	Speed, cpm	Remarks
E1A15	85.5			Static test to failure
E1C23	85.25			Static test to failure
E1C8	83	36	2	
E1C4	83	52	2	
E1C27	80	100	2	
E1A24	80	378	180	
E1C24	70	848	180	
E1A23	70	1,375	180	
E1C26	65	1,689	180	
E1C11	65	1,910	180	
E1D17	60	2,245	180	
E1C21	60	3,014	180	
E1C18	50	11,000	1,800	
E1C15	50	12,000	1,800	
E1D5	40	17,367	180	
E1A5	40	40,000	1,800	
E1D21	40	48,000	1,800	
E1C6	30	160,000	1,800	
E1A1	30	217,000	1,800	
E1C25	28	214,000	1,800	
E1A9	28	20,054,000	1,800	Did not fail
E1C22	27	20,779,000	1,800	Did not fail
E1C19	26	54,272,000	1,800	Did not fail
E1A19	24	64,052,000	1,800	Did not fail
E1A27	20	36,196,000	1,800	Did not fail

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TABLE IV.- FATIGUE TEST RESULTS FOR 403 STAINLESS-STEEL MATERIAL UNDER DIRECT STRESS AT R = 0

(a) Unnotched sheet specimens

Specimen	Maximum stress, ksi	Fatigue life, cycles	Speed, cpm	Remarks
F1A30	194.6			Static test to failure
F1D1	185	15	180	
F1C19	182	9,720	180	
F1D19	182	9,915	180	
F2C2	180	4,750	180	
F1A2	180	8,418	180	
F1B14	170	14,619	180	
F1D18	160	31,000	1,800	
F1B5	160	38,000	1,800	
F1C15	150	51,000	1,800	
F1B19	150	52,000	1,800	
F1A28	140	48,000	1,800	Failed 0.20 in. out of middle inch
F1D20	140	69,000	1,800	
F1A19	140	72,000	1,800	
F1C8	130	74,000	1,800	
F1B28	130	97,000	1,800	
F1B2	120	85,000	1,800	
F1C9	120	132,000	1,800	
F1B20	110	180,000	1,800	
F1C11	110	343,000	1,800	Failed 0.50 in. out of middle inch
F1C18	110	549,000	1,800	
F1A21	105	335,000	1,800	
F1C29	105	865,000	1,800	
F1A5	103	149,000	1,800	
F1A4	103	283,000	1,800	
F1B3	100	149,000	1,800	Failed at surface flaw
F1C5	100	420,000	1,800	
F1B16	100	33,871,000	1,800	Did not fail
F1B7	90	35,540,000	1,800	Did not fail

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TABLE IV.- FATIGUE TEST RESULTS FOR 403 STAINLESS-STEEL MATERIAL UNDER DIRECT STRESS AT R = 0 - Concluded

(b) Notched sheet specimens, $K_T = 2$

Specimen	Maximum stress, ksi	Fatigue life, cycles	Speed, cpm	Remarks
F1A33	207			Static test to failure
F1C24	195	716	2	
F1B4	175	834	2	
F1B17	150	3,232	180	
F1B31	135	6,648	180	
F1B13	120	24,000	1,800	
F1C23	110	23,000	1,800	
F1D15	100	37,000	1,800	
F1B1	90	71,000	1,800	
F1B11	80	83,000	1,800	
F1B12	70	170,000	1,800	
F1C3	65	284,000	1,800	
F1A32	62.5	218,000	1,800	
F1D5	60	22,236,000	1,800	

(c) Notched sheet specimens, $K_T = 4$

Specimen	Maximum stress, ksi	Fatigue life, cycles	Speed, cpm	Remarks
F1A8	204			Static test to failure
F1C6	200	19	2	
F1C16	180	129	2	
F1A25	160	252	2	
F1D13	140	922	180	
F1A3	120	1,903	180	
F1C28	100	3,667	180	
F1C31	80	14,000	1,800	
F1D8	50	89,000	1,800	
F1A6	40	10,644,000	1,800	
F1D14	38	1,798,000	1,800	
F1D7	35	41,709,000	1,800	Did not fail

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DIA1	DIA7	DIA13	DIA19	DIA25	DIA31	DIA37	DIA43
DIB1	DIB7	DIB13	DIB19	DIB25	DIB31	DIB37	DIB43
DIC1	DIC7	DIC13	DIC19	DIC25	DIC31	DIC37	DIC43
DIA2	DIA8	DIA14	DIA20	DIA26	DIA32	DIA38	DIA44
DIB2	DIB8	DIB14	DIB20	DIB26	DIB32	DIB38	DIB44
DIC2	DIC8	DIC14	DIC20	DIC26	DIC32	DIC38	DIC44
DIA3	DIA9	DIA15	DIA21	DIA27	DIA33	DIA39	DIA45
DIB3	DIB9	DIB15	DIB21	DIB27	DIB33	DIB39	DIB45
DIC3	DIC9	DIC15	DIC21	DIC27	DIC33	DIC39	DIC45
DIA4	DIA10	DIA16	DIA22	DIA28	DIA34	DIA40	DIA46
DIB4	DIB10	DIB16	DIB22	DIB28	DIB34	DIB40	DIB46
DIC4	DIC10	DIC16	DIC22	DIC28	DIC34	DIC40	DIC46
DIA5	DIA11	DIA17	DIA23	DIA29	DIA35	DIA41	DIA47
DIB5	DIB11	DIB17	DIB23	DIB29	DIB35	DIB41	DIB47
DIC5	DIC11	DIC17	DIC23	DIC29	DIC35	DIC41	DIC47
DIA6	DIA12	DIA18	DIA24	DIA30	DIA36	DIA42	DIA48
DIB6	DIB12	DIB18	DIB24	DIB30	DIB36	DIB42	DIB48
DIC6	DIC12	DIC18	DIC24	DIC30	DIC36	DIC42	DIC48

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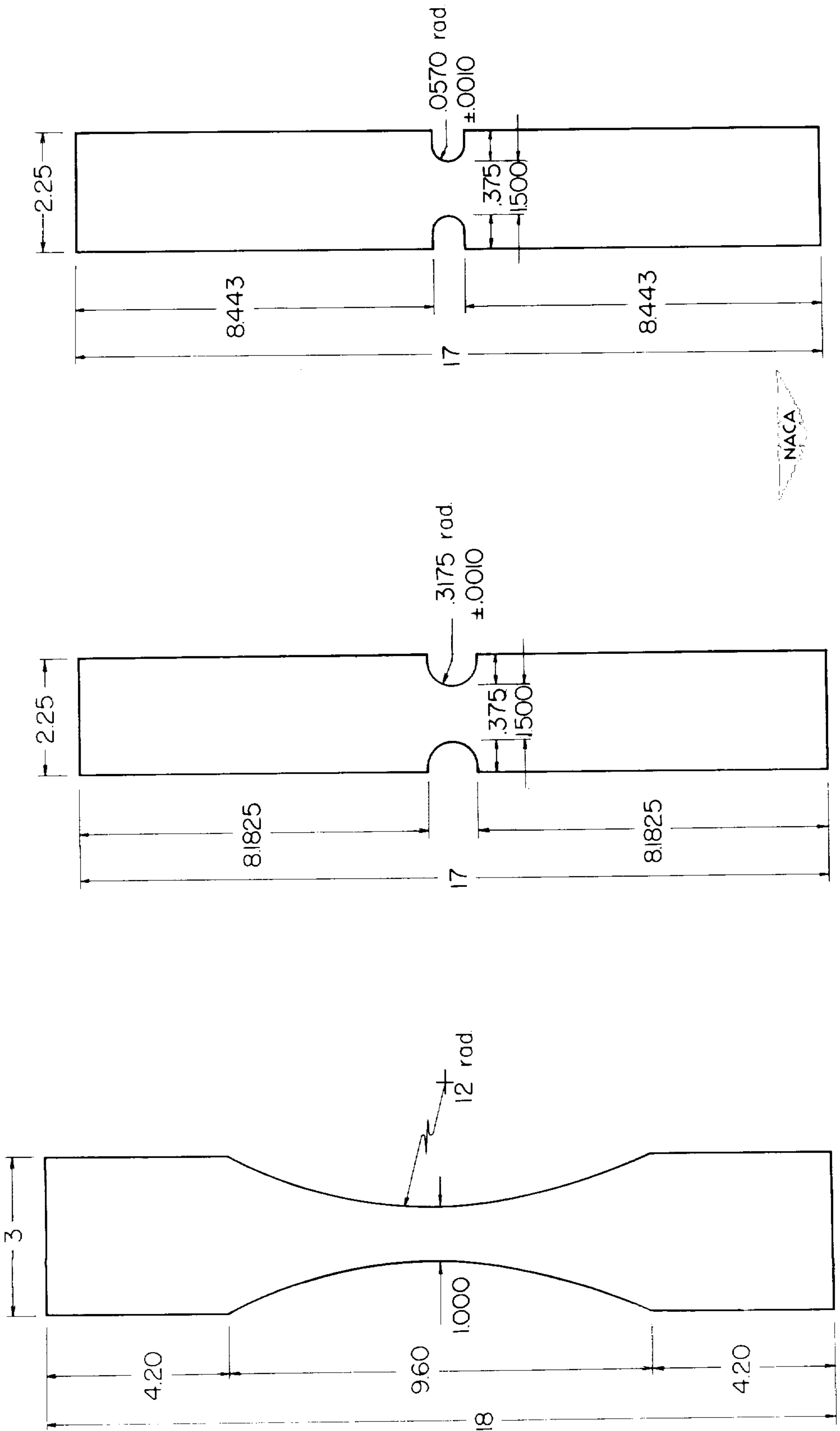
Figure 1.- Sheet layout for 61S-T6 aluminum-alloy material.
Sheet size, 4 feet by 12 feet.

E1D1	E1D5	E1D9	E1D13	E1D17	E1D21	E1D25
E1C1	E1C5	E1C9	E1C13	E1C17	E1C21	E1C25
E1B1	E1B5	E1B9	E1B13	E1B17	E1B21	E1B25
E1A1	E1A5	E1A9	E1A13	E1A17	E1A21	E1A25
E1C2	E1C6	E1C10	E1C14	E1C18	E1C22	E1C26
E1B2	E1B6	E1B10	E1B14	E1B18	E1B22	E1B26
E1A2	E1A6	E1A10	E1A14	E1A18	E1A22	E1A26
E1A3	E1A7	E1A11	E1A15	E1A19	E1A23	E1A27
E1B3	E1B7	E1B11	E1B15	E1B19	E1B23	E1B27
E1C3	E1C7	E1C11	E1C15	E1C19	E1C23	E1C27
E1A4	E1A8	E1A12	E1A16	E1A20	E1A24	E1A28
E1B4	E1B8	E1B12	E1B16	E1B20	E1B24	E1B28
E1C4	E1C8	E1C12	E1C16	E1C20	E1C24	E1C28
E1D4	E1D8	E1D12	E1D16	E1D20	E1D24	E1D28

Figure 2.- Sheet layout for 347 stainless-steel material. Sheet size, 3 feet by 10 feet.



(a) Unnotched.

(b) $K_T = 2$.

(c) $K_T = 4$.

Figure 3.- Specimen configurations. (All dimensions are in inches.)

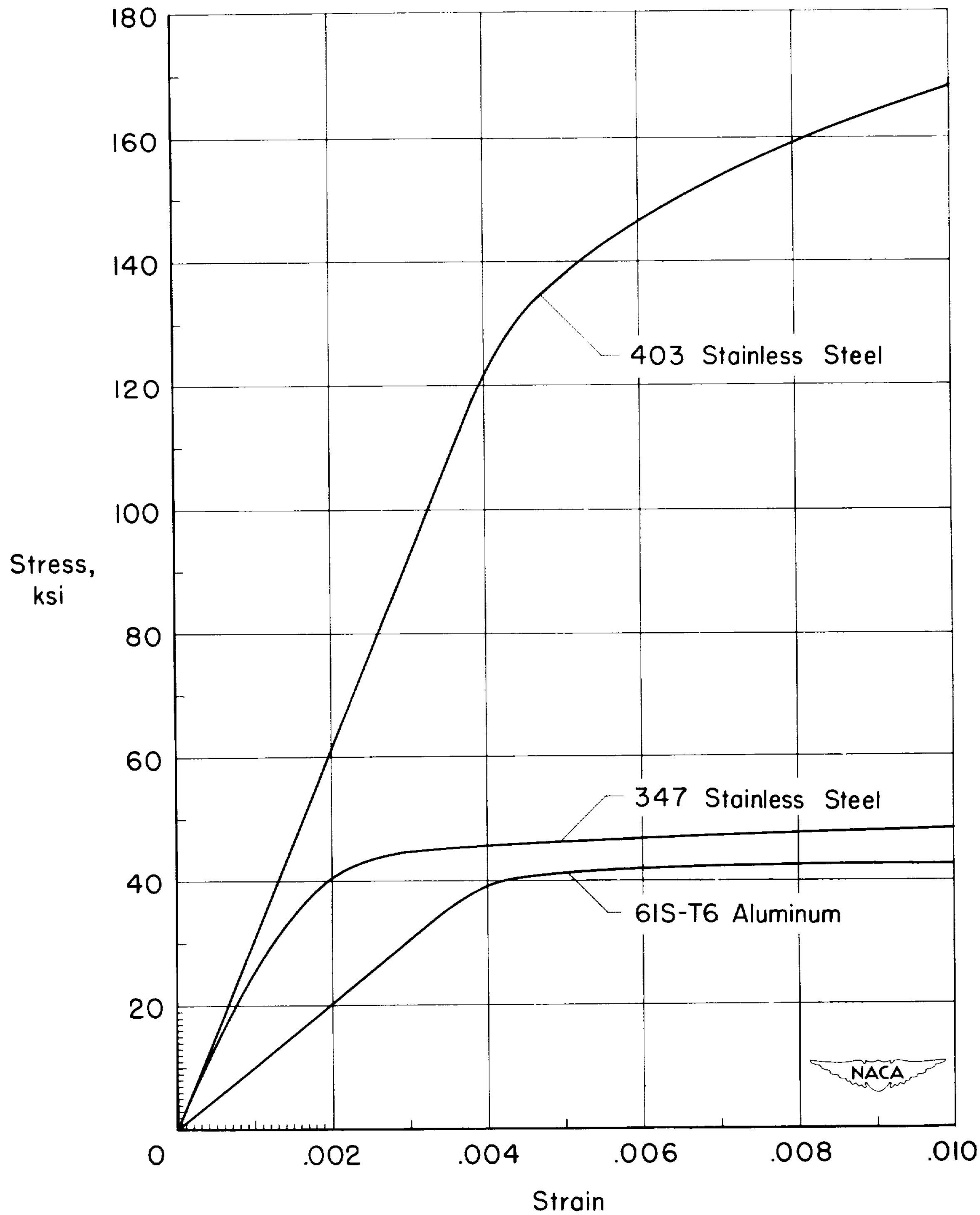


Figure 4.- Tensile stress-strain curves for materials used.

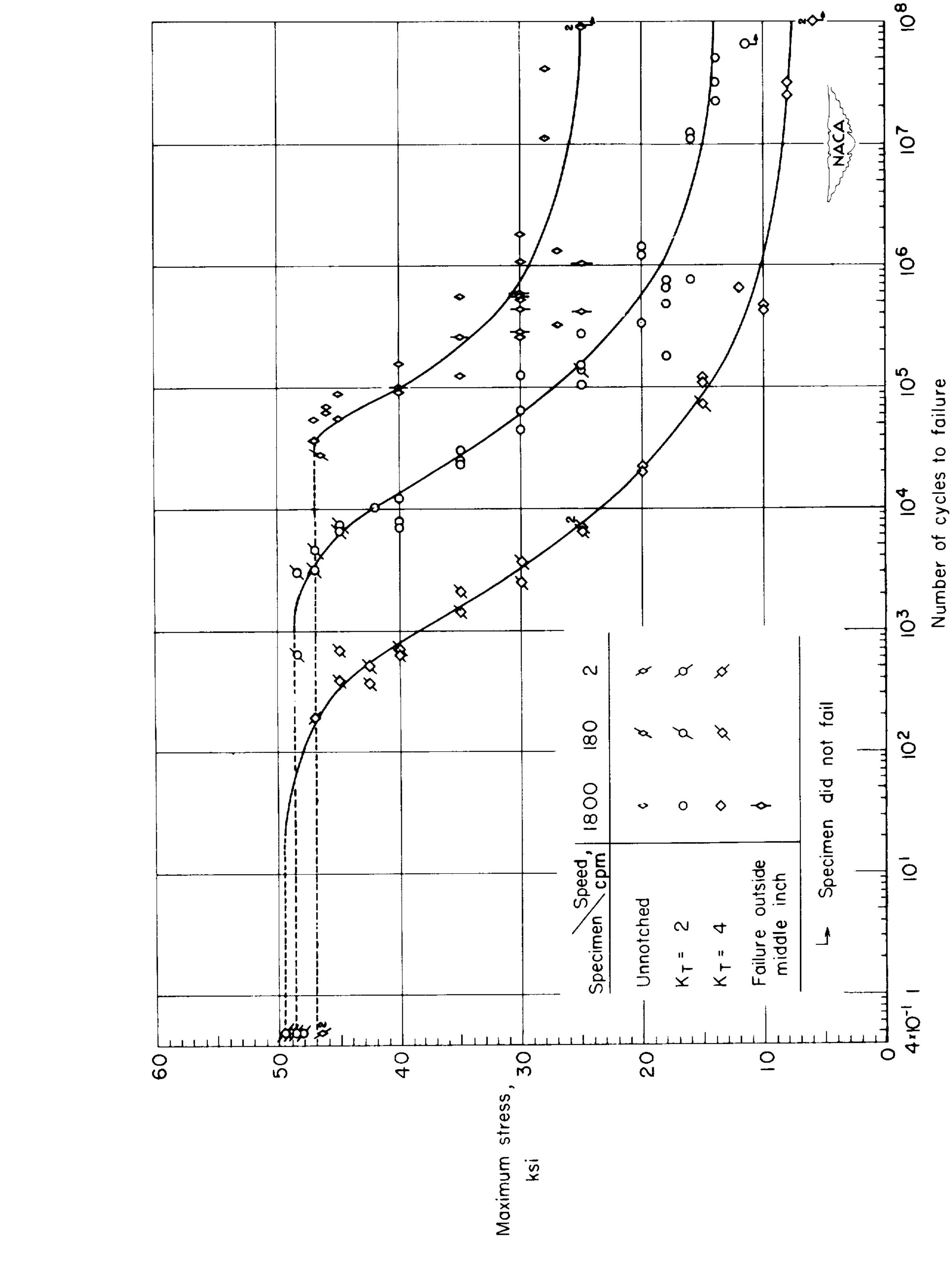


Figure 5.- Results of fatigue tests on 61S-T6 aluminum-alloy specimens under axial load at R = 0.

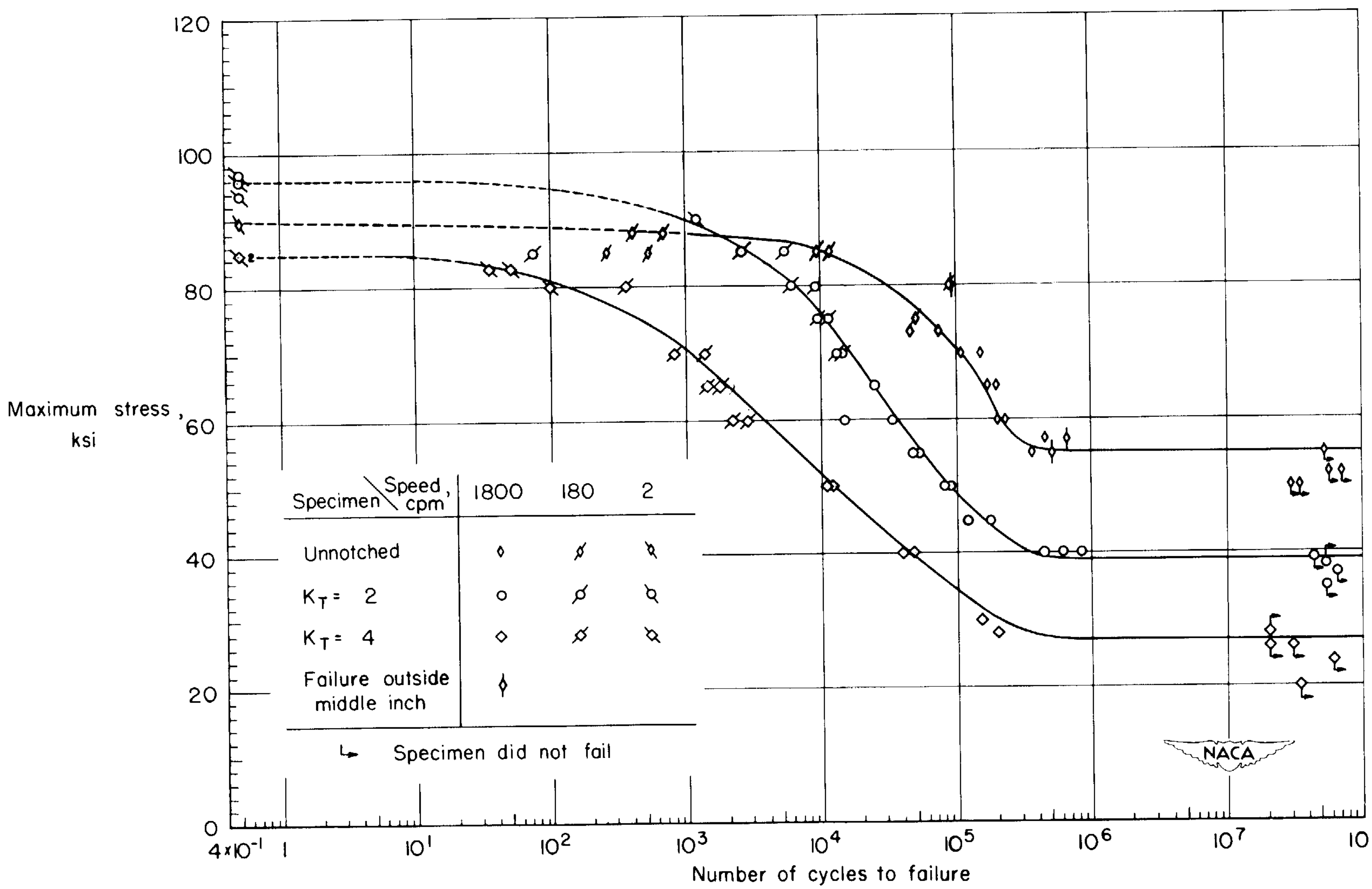


Figure 6.- Results of fatigue tests on 347 stainless-steel specimens under axial load at $R = 0$.

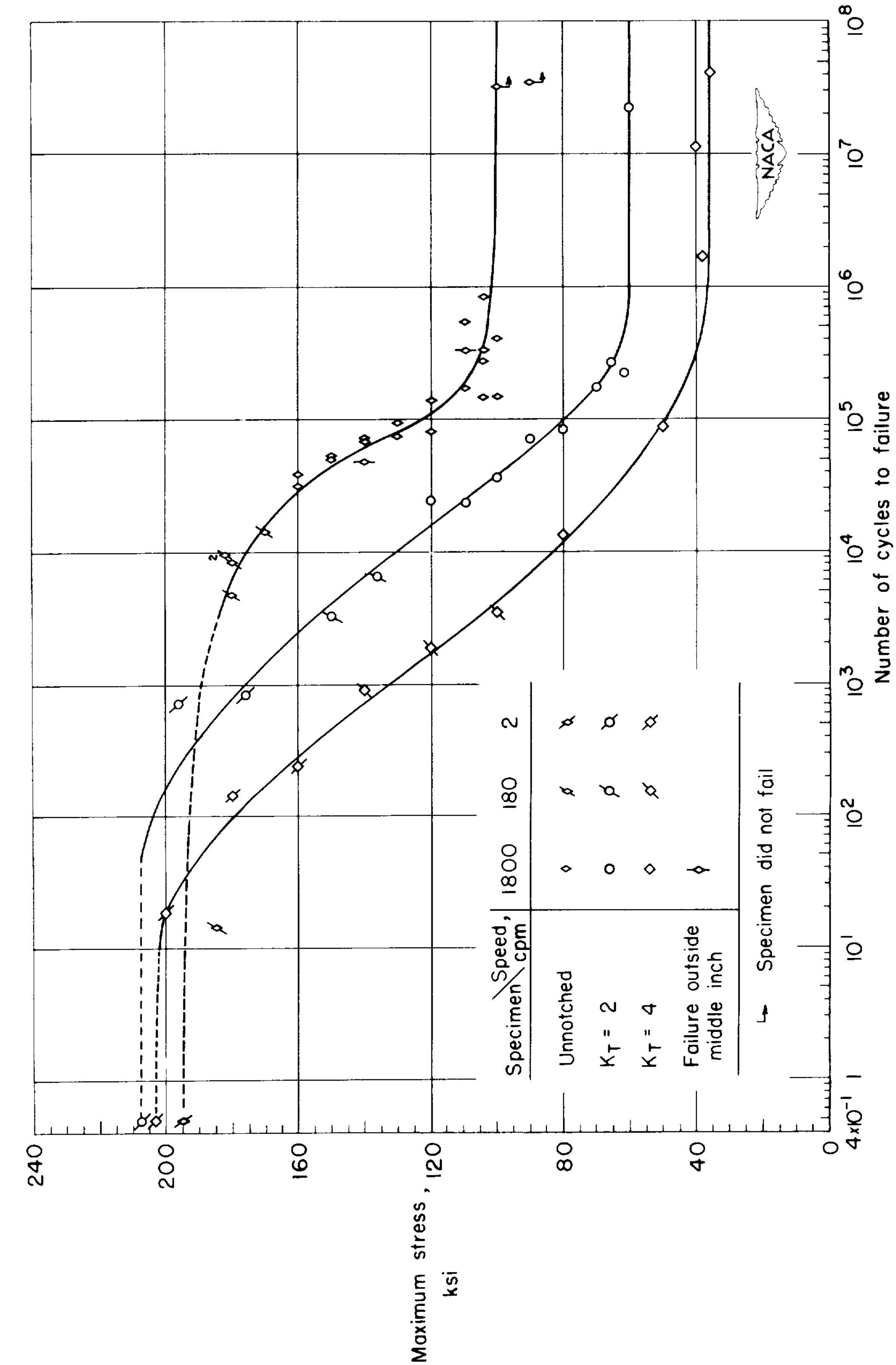


Figure 7.- Results of fatigue tests on 403 stainless-steel specimens under axial load at $R = 0$.

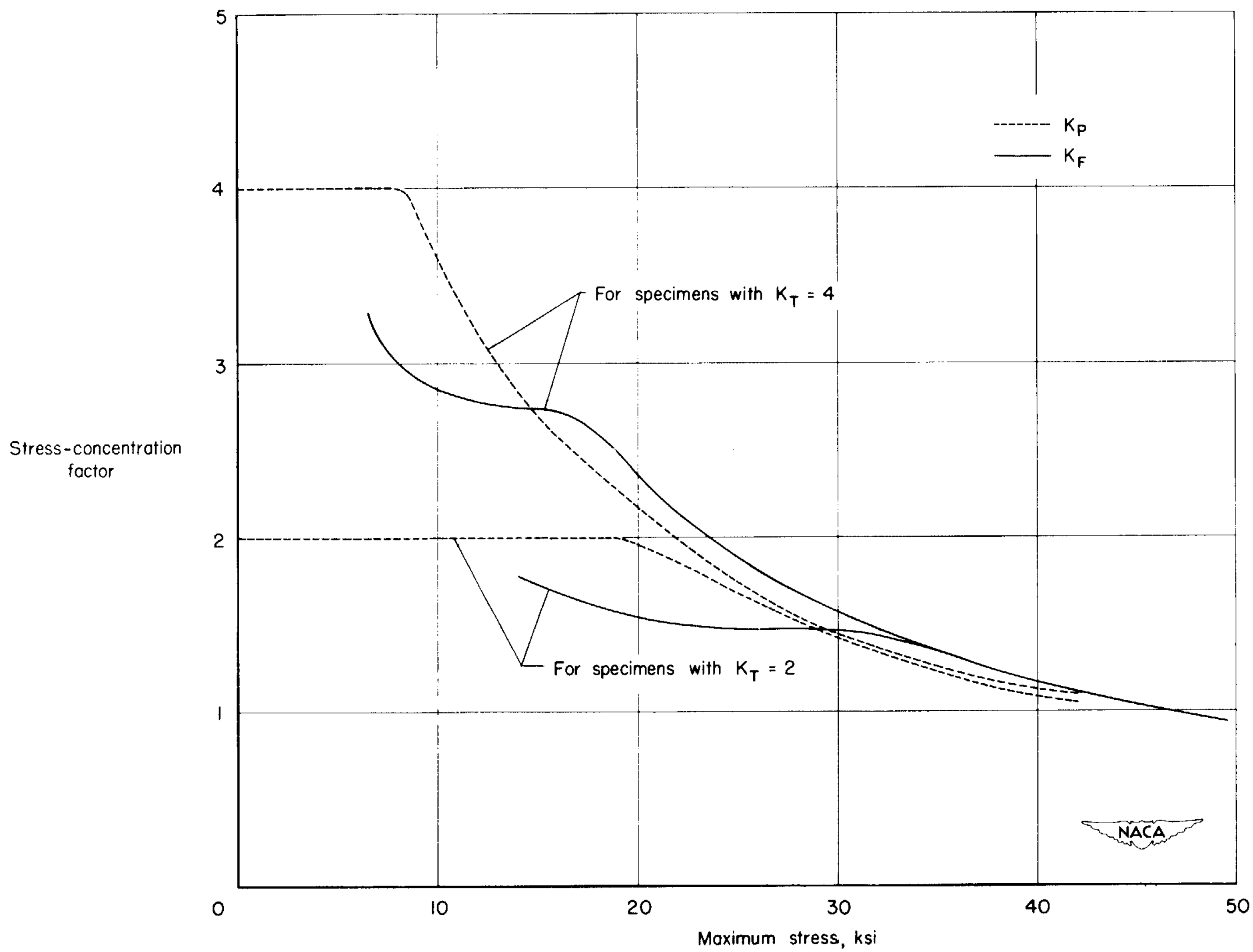


Figure 8.- Variation in K_F for tests on 61S-T6 aluminum-alloy specimens.

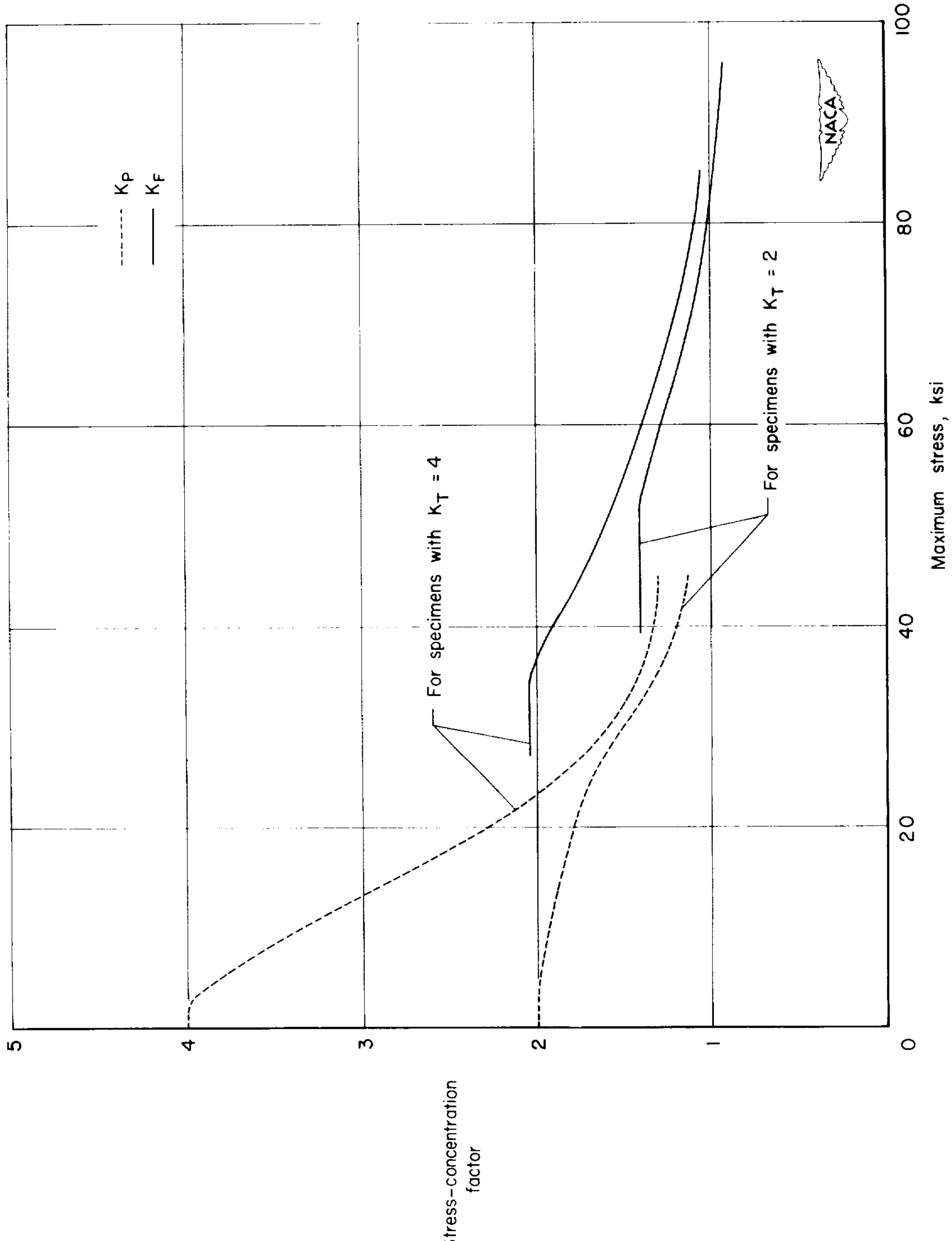


Figure 9.- Variation in K_F for tests on 347 stainless-steel specimens.

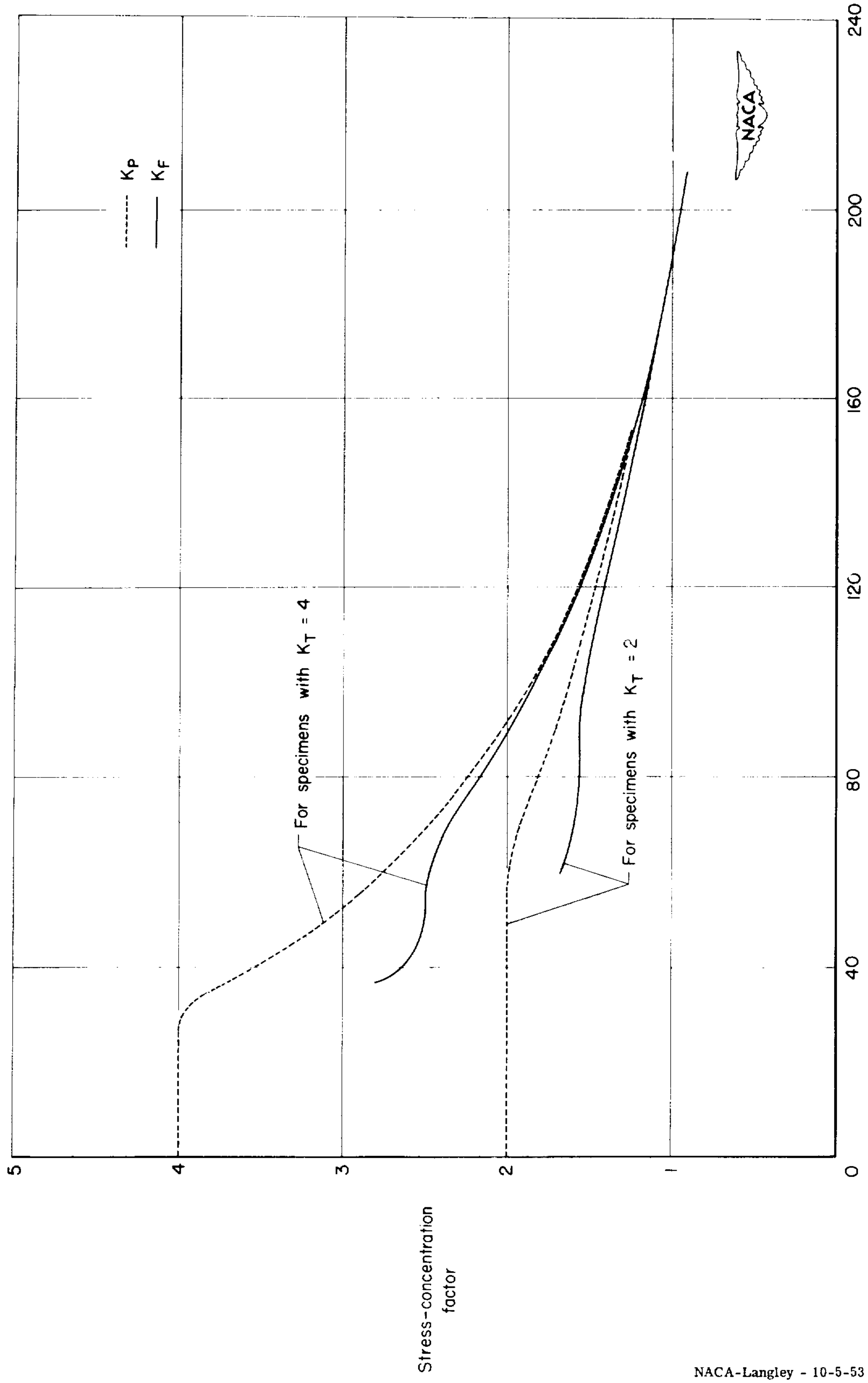


Figure 10.- Variation in K_F for tests on 403 stainless-steel specimens.

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Copies obtainable from NACA, Washington

1. Loads and Stresses, Structural - Concentrated (4.3.7.6)
2. Loads and Stresses, Structural - Repeated Dynamic (4.3.7.7.1)
3. Aluminum (5.1.1)
4. Steels (5.1.3)
5. Materials, Properties - Tensile (5.2.1)
6. Materials, Properties - Fatigue (5.2.5)
7. Materials, Properties - Plasticity (5.2.13)

I. Hardrath, Herbert F.
II. Landers, Charles B.
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IV. NACA TN 3017

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